Solid State Chemistry
- Amorphous Materials -

http://noncry.kuicr.kyoto-u.ac.jp

Prof
YOKO, Toshinobu
(D Eng)

Assoc Prof
TAKAHASHI, Masahide
(D Sc)

Instr
TOKUDA, Yomei
(D Eng)

Assoc Instr
ENKHTUVSHIN, Dorjpalam

A Res
MENAA, Bouzid
(D Eng)

PD
YAO, Jianxi
(D Eng)

PD
KAKIUCHIDA, Hiroshi
(D Eng)

Guest Res Assoc
KE, Shao
(D Sc)

Students

ZHAN, Jian (D3)
SAITO, Masanori (M2)
HIDAKA, Kenji (M1)
FUKUDA, Masahiro (RF)
TOMOYOSHI, Yoshio (RF)
MASAI, Hirokazu (D2)
YAMAMOTO, Satomi (M2)
INOUE, Haruo (UG)
FUKUDA, Masaaki (RF)
MIZUNO, Megumi (D1)
IKAWA, Hiroyuki (M1)
FUJII, Masao (UG)
KUNIYOSHI, Minoru (RF)

Scope of Research

In this laboratory, amorphous and polycrystalline inorganic materials with various optical functions such as photorefractive, optical nonlinearity and photo-catalysis are the target materials, which are synthesized by sol-gel, multicathode sputtering, melt-quenching and sintering methods. In order to obtain highly functional materials the structures are investigated by X-ray diffraction techniques, high-resoluction NMR, thermal analysis, various laser spectroscopies and ab initio molecular orbital calculations.

Research Activities (Year 2003)

Presentations

Photochemical Process of Divalent Germanium Responsible for Photorefractive Index Change in GeO_2-SiO_2 Glasses, Takahashi M, Sakoh A, Nishii J and Yoko T, X International Conference on the Physics of Non-Crystalline Solids, Italy, 13 - 17 July.

Organic-Inorganic Hybrid Low-Melting Glasses Consisting of Siloxane Bonds, Masai H, Takahashi M, Tokuda Y, Shimada R and Yoko T, X International Conference on the Physics of Non-Crystalline Solids, Italy, 13-17 July.

Local Structure of Lead Silicate Glasses, Mizuno M, Takahashi M, Takaishi T, Tokuda Y, and Yoko T, The 5th International Meeting of Pacific Rim Ceramic Societies Incorporating the 16th Fall Meeting of the Ceramic Society of Japan , 29 September - 2 October.

Photochemical Reactions Responsible for Photorefractive Index Change in Germanosilicate Glasses, Takahashi M, Sakoh A, Yoko T *et al*, Glass & Optical Materials Division Meeting, USA, 12 - 15 October.

Thermal and Viscoelastic Properties of Organically Modified Hybrid Low-Melting Glasses Consisting of Siloxane Framework Prepared by Sol-Gel Melting Method, Yoko T, Masai H, Menaa B *et al*, Glass & Optical Materials Division Meeting, USA, 12 - 15 October.

Photochemical reactions responsible for photo-refractive index change in GeO_2-SiO_2 glasses

The ultraviolet-induced photochemical reactions in GeO_2-SiO_2 glasses is widely used to manufacture fiber Bragg gratings. The photochemical reaction of the divalent Ge (Ge^{2+}) which, we believe, is mainly responsible for the photorefractivity has been investigated by the photoluminescence spectroscopy. The excitation-emission mapping of the spectra reveals that the highly photo-active Ge^{2+} (PADGe) shows a large Stokes shift. This indicates that the local structure around the PADGe is allowed to relax due to the free space, resulting in the refractive index change. We have also fabricated the thermal-switching waveguide in the GeO_2-SiO_2 thin films.

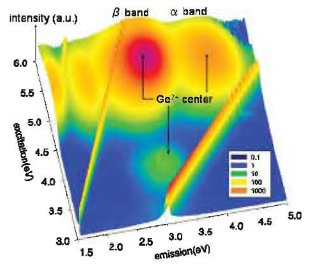

Fig. 1 A bird's-eye view of the PL spectrum mapping of as-deposited GeO_2-SiO_2 CVD film. The intensity axis is shown in logarithm scale.

6-coordinated Si in phosphate glasses

It has been demonstrated that Si in some sodium phosphate glasses takes a 6-coordinated structure, while it does exist as a 4-coordinated structure in conventional oxide glasses. We have investigated the detailed local structure of 6-coordinated Si, Si(6), in the glasses and then proposed the formation mechanism by means of ^{29}Si and ^{31}P MAS NMR spectroscopy and ab initio molecular orbital (MO) calculations. The ratios of an increment of P with 3 bridging-oxygens, P(Q3), to that of Si(6) were determined as about 2, indicating that the formation of one Si(6) needs two P(3)'s. The ab initio MO calculations have shown that the energy of a model with Si(6) octahedrally coordinated by six P(Q3)'s is lower than that of Si tetrahedrally coordinated by four P(3)'s, Si(4) by 1.9eV. Therefore, Si(6) is more stable in sodium phosphate glasses than Si(4).

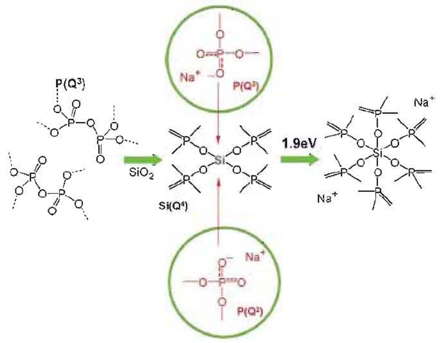

Fig. 2 Formation mechanism of a local structure of 6-coordinated Si, Si(6). The stabilization energy of a cluster with Si(6) has been calculated as 1.9eV.

Preparation of organic/inorganic low-melting glass thick-films

Pollutant-free low-melting glasses are considered to have potential applications in the active optical devices. Recently, we have developed organic/inorganic hybrid low-melting glasses by the sol-gel melting method. Thick films of over 10 μm can be obtained using dip-coating method. The absolute roughness of the film has been determined as $8.5*10^{-4}$ μm by AFM. The propagation loss of film has been also measured as less than 1 dB/cm at 1553 nm.

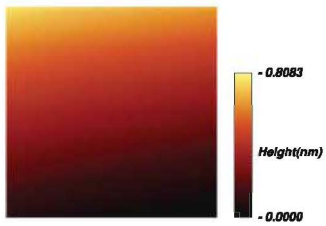

Fig. 3 Atomic force microscopy topography for low-melting glass. The observed area is 50 * 50 μm. The film thickness is 3.25 μm and the absolute roughness is $8.5*10^{-4}$ μm

Grants

Yoko T, Photochemical reactivity of glasses, Grant-in-Aid for Scientific Research (A) (2), 1 April 2001 - 31 March 2005.

Takahashi M, Development of photorefractive low-melting glasses, Grant-in-Aid for Scientific Research (B) (2), 1 April 2001 - 31 March 2005.

Takahashi M, Development of photonics materials based on the organic-inorganic hybrid low melting glasses, PRESTO, Japan Science and Technology, 1 November 2002 - 31 October 2005.

Award

TAKAHASHI M, Japan-Australasian Ceramic Society Joint Ceramic Award, Study on the Optical Functional Glasses Doped with Active Centers, The Ceramic Society of Japan and Australasian Ceramic Society, 30 May 2003.